Ontario

Computer Engineering Technology Program Standard

The approved program standard for all Computer Engineering Technology programs of instruction leading to an Ontario College Advanced Diploma delivered by Ontario Colleges of Applied Arts and Technology (MTCU funding code 60509)

Ministry of Training, Colleges and Universities
February 2006

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Inquiries regarding specific Computer Engineering Technology programs offered by colleges of applied arts and technology in Ontario should be directed to the relevant college.

This version replaces the program standard released in August 1998. Inquiries regarding this program standard should be directed to the address noted above.

This publication is available on the Ministry's Web site at http://www.edu.gov.on.ca

Cette publication est également disponible sur le site Web du ministère: http://www.edu.gov.on.ca

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ISBN 1-4249-0386-6
ISBN 1-4249-0388-2 (PDF)
ISBN 1-4249-0387-4 (HTML)

Ce document est aussi disponible en français.

2007-00325

Acknowledgements

The Ministry of Training, Colleges and Universities acknowledges with thanks the significant contribution of the many individuals and organizations who participated in the review of this program standard. In particular, the Ministry of Training, Colleges and Universities would like to acknowledge the important roles of

- All those who participated in the focus groups in Sault Ste. Marie, Sudbury, Toronto, Kitchener, Kingston, and Peterborough, and to the many individuals and organizations who participated in the mail-based consultations.

- The coordinators of Computer Engineering Technology Programs for their assistance throughout the project, and the project officer who led the review of the vocational standard, Devon Galway, Algonquin College, and the project officer who completed the validation and approval processes, Bill Fallis, George Brown College.

- The joint working group of the College Committee of Vice-Presidents, Academic (CCVPA) and the General Education / Generic Skills coordinators group, who re-articulated the generic skills learning outcomes (now the Essential Employability Skills) and the general education policy (now the General Education Requirement) in light of the Credentials Framework.

- The Committee of the Association of Canadian Community Colleges (ACCC) and of Human Resources Development Canada (HRDC) for the use of its definition of Essential Employability Skills (EES).

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I. Introduction

This document is the Program Standard for all Computer Engineering Technology programs of instruction leading to an Ontario College Advanced Diploma delivered by Ontario colleges of applied arts and technology (MTCU funding code 60509). This version replaces the one released in August 1998.

Development of System-Wide Program Standards

In 1993, the Government of Ontario initiated program standards development with the objectives of bringing a greater degree of consistency to college programming offered across the province, broadening the focus of college programs to ensure graduates have the skills to be flexible and to continue to learn and adapt, and providing public accountability for the quality and relevance of college programs.

The Colleges Branch of the Ministry of Training, Colleges and Universities has responsibility for the development, review, and approval of system-wide standards for programs of instruction at Ontario colleges of applied arts and technology.

Program Standards

Program standards apply to all similar programs of instruction offered by colleges across the province. Each program standard for a postsecondary program includes the following elements:

- **Vocational standard** (the vocationally specific learning outcomes which apply to the program of instruction in question),
- **Essential employability skills** (the essential employability skills learning outcomes which apply to all programs of instruction), and
- **General education requirement** (the requirement for general education in postsecondary programs of instruction).

Collectively, these elements outline the essential skills and knowledge that a student must reliably demonstrate in order to graduate from the program.

Individual colleges of applied arts and technology offering the program of instruction determine the specific program structure, delivery methods, and other curriculum matters to be used in assisting students to achieve the outcomes articulated in the standard. Individual colleges also determine whether additional local learning outcomes will be required to reflect specific local needs and/or interests.

The Expression of Program Standards as Learning Outcomes

Learning outcomes represent culminating demonstrations of learning and achievement. They are not simply a listing of discrete skills, nor broad statements of knowledge and comprehension. In addition, learning outcomes are interrelated and cannot be viewed in isolation of one another. As such, they should be viewed as a comprehensive whole. They describe performances that demonstrate that significant integrated learning by graduates of the program has been achieved and verified.

Expressing standards as learning outcomes ensures consistency in the outcomes for program graduates, while leaving to the discretion of individual colleges curriculum matters such as the specific program structure and delivery methods.

The Presentation of the Learning Outcomes

The **learning outcome** statement sets out the culminating demonstration of learning and achievement that the student must reliably demonstrate before graduation.

The **elements of the performance** for each outcome define and clarify the level and quality of performance necessary to meet the requirements of the learning outcome. However, it is the performance of the learning outcome itself on which students are evaluated. The elements are indicators of the means by which the student may proceed to satisfactory performance of the learning outcome. The elements do not stand alone but rather in reference to the learning outcome of which they form a part.

The Development of a Program Standard

In establishing the standards development initiative, the Government determined that all postsecondary programs of instruction should include vocational skills coupled with a broader set of essential skills. This combination is considered critical to ensuring that college graduates have the skills required to be successful both upon graduation from the college program and throughout their working and personal lives.

A program standard is developed through a broad consultation process involving a range of stakeholders with a direct interest in the program area, including employers, professional associations, universities, secondary schools, and program graduates working in the field, in addition to students, faculty, and administrators at the colleges themselves. It represents a consensus of participating stakeholders on the essential learning that all program graduates should have achieved.

Updating the Program Standard

The Ministry of Training, Colleges and Universities will undertake regular reviews of the vocational learning outcomes for this program to ensure that the Computer Engineering Technology Program Standard remains appropriate and relevant to the needs of students and employers across the Province of Ontario. To confirm that this document is the most up-to-date release, contact the Ministry of Training, Colleges and Universities at the address or telephone number noted on the inside cover page.

II. Vocational Standard

All graduates of Computer Engineering Technology programs of instruction must have achieved the nine vocational learning outcomes listed in the following pages, in addition to achieving the essential employability skills learning outcomes and meeting the general education requirement.

Preamble

Increasingly, individuals and organizations look to computers, be they stand-alone or networked, to optimize workflow, establish a presence in global markets, improve communication. This pervasive integration of computers and their associated technologies has led to an emergence of job opportunities in the creation, integration, and support of technology systems and infrastructures.

Ontario's colleges of applied arts and technology offer a wide variety of computer-related programs that prepare graduates for both existing and emerging opportunities in our society. At the heart of the computer technology education provided to Ontario college students is the ability to think critically, solve problems, and acquire new skills quickly. While these abilities are practised and enhanced in the context of a particular expertise, they are also transportable, with a reasonable training period, to other areas of expertise involving computers and their associated technologies.

Graduates of Computer Engineering Technology programs have acquired the knowledge and practical experience to continue to extend the application and ubiquitous nature of computing technology into our daily lives. As such, graduates are able to work individually or as part of a team to analyze, design, implement, and maintain software applications and hardware devices that make up computing devices and computer systems. From integrating existing components to building new ones, graduates work in a broad range of employment settings within the High Technology sector in both large and small organizations, as well as in any business that relies on the advantages of computer systems.

While the vocational learning outcomes for programs, such as Computer Engineering Technology, articulate the depth and breadth of skills, knowledge, and attitudes required by graduates when entering the work force, individual college programs may choose to build on this standard by offering some degree of specialization. Irrespective of the specialization, graduates' learning is significantly enhanced by opportunities for as much practical experience as is feasible during their time in the program.

There are many opportunities for graduates to pursue further educational qualifications; graduates may be granted credits towards a degree or certification through articulation agreements between the colleges and universities. Students should contact individual colleges for further details of a college's articulation agreements.

To be successful in a computer technology environment requires an ongoing commitment from the graduate to continue to update his/her skills to stay current in this rapidly changing field. Making use of knowledge and experience gained during their studies, graduates may also choose to apply for professional designations from provincial, national, and international organizations as a further demonstration of their commitment to keep their skills current.

Synopsis of the Vocational Learning Outcomes
Computer Engineering Technology Programs

The graduate has reliably demonstrated the ability to

1. **diagnose, solve, troubleshoot, and document technical problems involving computing devices using appropriate methodologies.**

2. **integrate multiple software and hardware components using appropriate network architecture.**

3. **participate in analyzing, planning, designing, and developing the architecture of computing devices and systems.**

4. **plan, install, configure, modify, test, and maintain a variety of computer systems to meet functional requirements.**

5. **apply principles of digital and analog circuits to the implementation of embedded computing devices.**

6. **analyze, build, test, implement, and maintain applications.**

7. **evaluate and document security issues associated with a variety of computing devices and propose alternatives to increase product reliability.**

8. **articulate, defend, and conform to workplace expectations found in technology environments.**

9. **contribute to the successful completion of the project applying the project management principles in use.**

Note: The learning outcomes have been numbered as a point of reference; numbering does not imply prioritization, sequencing, nor weighting of significance.

The Vocational Learning Outcomes

1. *The graduate has reliably demonstrated the ability to*

   diagnose, solve, troubleshoot, and document technical problems involving computing devices using appropriate methodologies.

Elements of the Performance

- Analyze technical problems and seek out appropriate troubleshooting procedures
- Acquire and use relevant technical information from a variety of sources (e.g., FAQs, knowledge bases, online support, and vendor help desks)
- Develop appropriate troubleshooting procedures, as required
- Monitor, review, and assess the effectiveness of the troubleshooting procedure
- Document the troubleshooting procedure
- Document the root cause of the problem and communicate the corrective action(s) clearly to the appropriate individual, as required
- Follow appropriate health and safety procedures
- Maintain records and historical data, as required
- Select and use appropriate equipment, instruments, and tools to diagnose technical problems
- Prepare schedules of maintenance
- Recognize personal limits and seek assistance in a timely manner to resolve problems beyond own knowledge and skills

2. *The graduate has reliably demonstrated the ability to*

integrate multiple software and hardware components using appropriate network architecture.

Elements of the Performance

- Apply principles of software and hardware integration (e.g., bar code scanners, radio frequency identification scanners, debit card readers, biometric security solutions)
- Apply basic principles of a variety of control systems and processes as required (e.g., robotics, point of sale systems, process control, sequential control)
- Integrate TCP/IF stack for communication with remote devices and applications
- Apply basic principles of firmware integration
- Develop solutions based on network technologies
- Apply knowledge of device connectivity, networks, and telecommunications
- Identify, assess, and select the appropriate medium and topology for a communications system
- Use a variety of strategies, tools, and techniques to integrate technologies
- Apply knowledge of industry standard protocols that relate to software and hardware
- Apply knowledge of security protocols and procedures
- Apply knowledge of common data and communication protocols and protocol analysis
- Resolve interoperability issues affecting the integration of software and hardware components

3. *The graduate has reliably demonstrated the ability to*

participate in analyzing, planning, designing, and developing the architecture of computing devices and systems.

Elements of the Performance

- Conduct a needs assessment and determine requirements
- Apply knowledge of issues related to systems connectivity
- Apply knowledge of a variety of computing platforms and associated software
- Develop appropriate testing policies and procedures
- Apply knowledge of industry standard protocols
- Identify constraints and risks
- Incorporate off-the-shelf products and solutions in the design, where feasible
- Participate in the design of infrastructure, application, and hardware systems according to appropriate standards, as required
- Support the design of embedded computing devices
- Apply knowledge of electrical and timing compatibility
- Use security principles to ensure that equipment and software can block unauthorized access
- Apply knowledge of product life cycles

4. *The graduate has reliably demonstrated the ability to*

plan, install, configure, modify, test, and maintain a variety of computer systems to meet functional requirements.

Elements of the Performance

- Determine and document the functional requirements of users and their organizations
- Apply knowledge of the management and monitoring of networks to the maintenance of computer systems
- Choose suitable computer components based on functional requirements
- Assist in the migration of software implementations to hardware, firmware, or embedded systems platforms
- Justify the choice of computer architecture based on functional requirements
- Document installation and configuration procedures
- Select and use standard tools, techniques, and equipment to modify, test, and maintain computer systems

5. *The graduate has reliably demonstrated the ability to*

apply principles of digital and analog circuits to the implementation of embedded computing devices.

Elements of the Performance

- Apply knowledge of digital circuit design to the implementation of embedded computing devices
- Apply knowledge of analog circuit design to the implementation of embedded computing devices
- Prepare circuit diagrams involving embedded computing devices
- Assess the electrical requirements of embedded computing devices
- Convert analog signals to digital signals and vice-versa
- Use data acquisition techniques to verify the implementation of embedded computing devices
- Apply knowledge of Real-Time Operating Systems

6. *The graduate has reliably demonstrated the ability to*

analyze, build, test, implement, and maintain applications.

Elements of the Performance

- Apply knowledge of user interface design
- Select and use an appropriate software development methodology
- Apply knowledge of a variety of programming languages
- Apply in-depth knowledge of programming approaches and practices (e.g., procedural, real-time, object-oriented, component-based)
- Apply a variety of analysis and design methodologies
- Apply knowledge of testing strategies, techniques, and tools
- Apply knowledge of debugging tools and techniques
- Apply knowledge of a variety of data structures
- Apply knowledge of a variety of mathematical principles and concepts to scale applications
- Assess and recommend software as required
- Analyze the implications of deploying a new application
- Apply knowledge of source code control when developing in a team environment
- Apply knowledge of programming techniques for real-time and embedded systems
- Prepare, present, and maintain current, clear, and accurate documentation
- Recognize the limitations of an embedded environment and the restrictions placed on software functionality
- Use a revision control system
- Use simulation to test configurations and interfaces prior to implementation
- Apply knowledge of assembly language as it relates to computer architecture
- Estimate costs for recommended solutions
- Consider security requirements when choosing a software development methodology
- Apply knowledge of the design, implementation, and querying of databases

7. *The graduate has reliably demonstrated the ability to*

evaluate and document security issues associated with a variety of computing devices and propose alternatives to increase product reliability.

Elements of the Performance

- Discuss the impacts of malicious software on the reliability of computing devices
- Recognize security risks in firmware, software, and hardware implementation
- Apply knowledge of communication ports to the protection of computing devices
- Research and use emerging secure communications protocols in the implementation of computing devices
- Apply knowledge of encryption algorithms to increase security
- Analyse and evaluate the source of the vulnerability (e.g., hardware, software, or firmware)
- Demonstrate the benefits and drawbacks of various security access levels
- Document the security risks of connecting computing devices to the Internet
- Respond appropriately to vulnerability disclosures, where required
- Keep abreast of technological advances in security controls
- Assess the role of security controls in the development and deployment of computing devices
- Determine the possible results of breaches in security
- Monitor emerging vulnerabilities and research new methods for detection and protection
- Perform quality assurance testing, where applicable
- Apply knowledge of authentication technologies to the protection of computing devices
- Apply knowledge of fault-tolerant computing and disaster-recovery techniques
- Apply knowledge of existing confidentiality and privacy regulations

8. *The graduate has reliably demonstrated the ability to*

articulate, defend, and conform to workplace expectations found in technology environments.

Elements of the Performance

- Recognize personal limits and seek assistance in a timely manner to resolve problems beyond own knowledge and skills
- Use language and terminology suited to the context
- Keep abreast of relevant technological change
- Advocate adherence to ethical principles and standards
- Follow organizational policies and procedures and facilitate the communication of updates
- Consider the ethical and social impacts of technology
- Use appropriate communication etiquette
- Identify guidelines set by appropriate organizations and bodies that prescribe quality programs, practices, processes, and procedures which apply to information technology environments (e.g., ISO, IEEE, CTAB)
- Ensure quality of assigned work
- Comply with software licensing requirements
- Participate in workplace mentoring programs
- Apply knowledge of existing confidentiality, privacy, and reporting regulations to daily work
- Contribute to the evaluation of organizational standards and procedures

9. *The graduate has reliably demonstrated the ability to*

contribute to the successful completion of the project applying the project management principles in use.

Elements of the Performance

- Participate in the planning, identification, scheduling, and assigning of tasks and resources involved in a project as required
- Contribute to the monitoring of resources and expenditures to maintain cost effectiveness and timelines as required
- Consolidate project updates regularly
- Estimate accurately the time required to complete project elements
- Complete project elements according to schedule
- Interpret and use project planning documents (e.g., Gantt Charts, Critical Path Analysis Charts, PERT Charts)
- Identify problems that will affect the project timeline and recommend changes as soon as possible
- Maintain current, clear, and accurate project-related documents which adhere to organizational and industry standards and procedures
- Use project management software

III. Essential Employability Skills

All graduates of Computer Engineering Technology programs of instruction must have reliably demonstrated the essential employability skills learning outcomes listed on the following pages, in addition to achieving the vocational learning outcomes and meeting the general education requirement.

Context

Essential Employability Skills (EES) are skills that, regardless of a student's program or discipline, are critical for success in the workplace, in day-to-day living, and for lifelong learning.

The teaching and attainment of these EES for students in, and graduates from, Ontario's colleges of applied arts and technology are anchored in a set of three fundamental assumptions:

- These skills are important for every adult to function successfully in society today.
- Our colleges are well equipped and well positioned to prepare graduates with these skills.
- These skills are equally valuable for all graduates, regardless of the level of their credential, whether they pursue a career path, or they pursue further education.

Skill Categories

To capture these skills, the following six categories define the essential areas where graduates must demonstrate skills and knowledge.

- Communication
- Numeracy
- Critical Thinking & Problem Solving
- Information Management
- Interpersonal
- Personal

Application / Implementation

In each of the six skill categories, there are a number of defining skills, or sub skills, identified to further articulate the requisite skills identified in the main skill categories. The following chart illustrates the relationship between the skill categories, the defining skills within the categories, and learning outcomes to be achieved by graduates from all postsecondary programs of instruction that lead to an Ontario College credential.

EES may be embedded in General Education or vocational courses, or developed through discrete courses. However these skills are developed, all graduates with Ontario College credentials must be able to reliably demonstrate the essential skills required in each of the six categories.

SKILL CATEGORY	**DEFINING SKILLS: Skill areas to be demonstrated by graduates:**	**LEARNING OUTCOMES: The levels of achievement required by graduates. The graduate has reliably demonstrated the ability to:**
COMMUNICATION	• Reading • Writing • Speaking • Listening • Presenting • Visual literacy	1. *communicate clearly, concisely and correctly in the written, spoken, and visual form that fulfills the purpose and meets the needs of the audience.* 2. *respond to written, spoken, or visual messages in a manner that ensures effective communication.*
NUMERACY	• Understanding and applying mathematical concepts and reasoning • Analyzing and using numerical data • Conceptualizing	3. *execute mathematical operations accurately.*
CRITICAL THINKING & PROBLEM SOLVING	• Analysing • Synthesising • Evaluating • Decision making • Creative and innovative thinking	4. *apply a systematic approach to solve problems.* 5. *use a variety of thinking skills to anticipate and solve problems.*
INFORMATION MANAGEMENT	• Gathering and managing information • Selecting and using appropriate tools and technology for a task or a project • Computer literacy • Internet skills	6. *locate, select, organize, and document information using appropriate technology and information systems.* 7. *analyze, evaluate, and apply relevant information from a variety of sources.*

SKILL CATEGORY	DEFINING SKILLS: Skill areas to be demonstrated by graduates:	LEARNING OUTCOMES: The levels of achievement required by graduates. The graduate has reliably demonstrated the ability to:
INTERPERSONAL	• Team work • Relationship management • Conflict resolution • Leadership • Networking	8. *show respect for the diverse opinions, values, belief systems, and contributions of others.* 9. *interact with others in groups or teams in ways that contribute to effective working relationships and the achievement of goals.*
PERSONAL	• Managing self • Managing change and being flexible and adaptable • Engaging in reflective practices • Demonstrating personal responsibility	10. *manage the use of time and other resources to complete projects.* 11. *take responsibility for one's own actions, decisions, and consequences.*

IV. General Education Requirement

All graduates of Computer Engineering Technology programs must have met the general education requirement described on the following pages, in addition to achieving the vocational and essential employability skills learning outcomes.

Requirement

The General Education Requirement for programs of instruction is stipulated in the Credentials Framework (Appendix A in the Minister's Binding Policy Directive *Framework for Programs of Instruction*).

While the inclusion of General Education is locally determined for programs of instruction leading to either a college certificate or an Ontario College Certificate, it is recommended that graduates of the Ontario College Certificate programs have been engaged in learning that incorporates some breadth beyond the vocational field of study.

In programs of instruction leading to either an Ontario College Diploma or an Ontario College Advanced Diploma, it is required that graduates have been engaged in learning that exposes them to at least one discipline outside their main field of study, and increases their awareness of the society and culture in which they live and work. This will typically be accomplished by students taking 3 to 5 courses (or the equivalent) designed discretely and separately from vocational learning opportunities.

This general education learning would normally be delivered using a combination of required and elective processes.

Purpose

The purpose of General Education in the Ontario college system is to contribute to the development of citizens who are conscious of the diversity, complexity, and richness of the human experience; who are able to establish meaning through this consciousness; and, who, as a result, are able to contribute thoughtfully, creatively, and positively to the society in which they live and work.

General Education strengthens student's essential employability skills, such as critical analysis, problem solving, and communication, in the context of an exploration of topics with broad-based personal and / or societal importance.

Themes

The themes listed below will be used to provide direction to colleges in the development and identification of courses that are designed to fulfil the General Education Requirement for programs of instructions.

Each theme provides a statement of Rationale and offers suggestions related to more specific topic areas that could be explored within each area. These suggestions are neither prescriptive nor exhaustive. They are included to provide guidance regarding the nature and scope of content that would be judged as meeting the intent and overall goals of General Education.

1. Arts in Society:

Rationale:
The capacity of a person to recognize and evaluate artistic and creative achievements is useful in many aspects of his/her life. Since artistic expression is a fundamentally human activity, which both reflects and anticipates developments in the larger culture, its study will enhance the student's cultural and self-awareness.

Content:
Courses in this area should provide students with an understanding of the importance of visual and creative arts in human affairs, of the artist's and writer's perceptions of the world and the means by which those perceptions are translated into the language of literature and artistic expression. They will also provide an appreciation of the aesthetic values used in examining works of art and possibly, a direct experience in expressing perceptions in an artistic medium.

2. Civic Life:

Rationale:
In order for individuals to live responsibly and to reach their potential as individuals and as citizens of society, they need to understand the patterns of human relationships that underlie the orderly interactions of a society's various structural units. Informed people will have knowledge of the meaning of civic life in relation to diverse communities at the local, national, and global level, and an awareness of international issues and the effects of these on Canada, and Canada's place in the international community.

Content:
Courses in this area should provide students with an understanding of the meaning of freedoms, rights, and participation in community and public life, in addition to a working knowledge of the structure and function of various levels of government (municipal, provincial, national) in Canada and/or in an international context. They may also provide an historical understanding of major political issues affecting relations between the various levels of government in Canada and their constituents.

3. Social and Cultural Understanding:

Rationale:
Knowledge of the patterns and precedents of the past provide the means for a person to gain an awareness of his or her place in contemporary culture and society. In addition to this awareness, students will acquire a sense of the main currents of their culture and that of other cultures over an extended period of time in order to link personal history to the broader study of culture.

Content:
Courses in this area are those that deal broadly with major social and cultural themes. These courses may also stress the nature and validity of historical evidence and the variety of historical interpretation of events. Courses will provide the students with a view and understanding of the impact of cultural, social, ethnic, or linguistic characteristics.

4. Personal Understanding:

Rationale:
Educated people are equipped for life-long understanding and development of themselves as integrated physiological and psychological entities. They are aware of the ideal need to be fully functioning persons: mentally, physically, emotionally, socially, spiritually, and vocationally.

Content:
Courses in this area will focus on understanding the individual: his or her evolution; situation; relationship with others; place in the environment and universe; achievements and problems; and his or her meaning and purpose. They will also allow students the opportunity to study institutionalized human social behaviour in a systematic way. Courses fulfilling this requirement may be oriented to the study of the individual within a variety of contexts.

5. Science and Technology:

Rationale:
Matter and energy are universal concepts in science, forming a basis for understanding the interactions that occur in living and non-living systems in our universe. Study in this area provides an understanding of the behaviour of matter that provides a foundation for further scientific study and the creation of broader understanding about natural phenomena.

Similarly, the various applications and developments in the area of technology have an increasing impact on all aspects of human endeavour and have numerous social, economic, and philosophical implications. For example, the operation of computers to process data at high speed has invoked an interaction between machines and the human mind that is unique in human history. This development and other technological developments have a powerful impact on how we deal with many of the complex questions in our society.

Content:
Courses in this area should stress scientific inquiry and deal with basic or fundamental questions of science rather than applied ones. They may be formulated from traditional basic courses in such areas of study as biology, chemistry, physics, astronomy, geology, or agriculture. As well, courses related to understanding the role and functions of computers (e.g., data management and information processing), and assorted computer-related technologies, should be offered in a non-applied manner to provide students with an opportunity to explore the impact of these concepts and practices on their lives.